Effects of Location on the Competitive Position of Mineral Exploration and Development Opportunities in Canada

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FOREWORD

This publication presents the results of independent research encouraged by the Centre for Resource Studies in the fields of mineral policy and economics. Support for studies on which the present work is based was received from the Nova Scotia and British Columbia governments.

The Centre's Working Paper Series is offered for information and discussion, in an attempt to encourage feedback to the authors and additional research by other workers. Views expressed are those of the authors, and do not necessarily represent the views of the Centre or its sponsors.

Margot J. Wojciechowski
Centre for Resource Studies

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SUMMARY

The variable economic conditions which exist within Canada have a direct bearing on the competitive position of mining and, consequently, influence corporate planning and the formulation of government policy. The paper formulates an evaluation procedure for examining the effects of location on the economics of mineral exploration targets and mine development opportunities. Inherent differences in the quality of mineral resources are not considered. These deposit-specific characteristics are held constant throughout the appraisal.

The methodology is applied to assess locational aspects of competitive position for Nova Scotia, New Brunswick, and Newfoundland in eastern Canada; Quebec, Ontario, Manitoba, and Saskatchewan in the central Canada region; and British Columbia in western Canada. The appraisal concerns two representative mine development opportunities: a medium-size open pit tungsten deposit, and a small underground gold deposit. The influence of regional economic conditions is initially assessed. Then, the consequences of taxation are isolated. Finally, the combined impact of regional conditions and taxation policies is examined.

While each province no doubt perceives that it hosts an above-average environment for mining investment, this is clearly not possible. Case study results indicate that large differences in mine development economics and exploration potential exist depending on the region and province in which deposits are situated. The reasons for these disparities have been examined and are found to result from the interaction of several key locational variables including wage rates, power charges, mining tax write-off provisions, regional differences in the investment credit for income tax, provincial corporate income tax rates, and several non-profit taxes.

In terms of motivating mining investment, Nova Scotia, New Brunswick, Quebec, and Saskatchewan, are generally found to rank towards the top of the Canadian league. At the other end of the league table, British Columbia appears to be out of step with the rest of the country. However, the substantial reduction in non-profit taxes associated with the 1985 British Columbia Budget is shown to significantly narrow the gap with other jurisdictions.

Utilizing the methodology developed in the paper, suggestions are made for future work to update the appraisal and to analyze this important and complex policy issue more comprehensively.

RESUME

Les conditions économiques variables qui existent au Canada ont des répercussions directes sur l'état compétitif de l'industrie minière et par conséquent influencent la planification des corporations et l'élaboration de la politique gouvernementale. Cette communication présente un procédé permettant d'évaluer les effets de l'emplacement sur l'économie des objectifs immédiats d'exploration minérale et des possibilités de mise en valeur des mines. On ne prend pas en considération les différences inhérentes à la qualité des ressources minérales. Ces caractéristiques spécifiques aux gisements sont considérées comme constantes au cours de l'évaluation.

On se sert de cette méthodologie pour évaluer les effets de l'emplacement sur l'état compétitif de la Nouvelle-Ecosse, du Nouveau-Brunswick et de Terre-Neuve dans l'est du Canada; du Québec, de l'Ontario, du Manitoba et de la Saskatchewan dans la région centrale du Canada, et de la Colombie-Britannique dans l'ouest du Canada. L'évaluation se rapporte à deux possibilités représentatives de mise en valeur de mines: d'une part à un gisement à ciel ouvert de taille moyenne de tungstène, et d'autre part à un petit gisement souterrain d'or. On évalue d'abord l'influence de la conjoncture économique régionale, ensuite les effets de la fiscalité, et enfin l'impact combiné des conditions régionales et des politiques fiscales.

Alors que chaque province est sans doute persuadée qu'elle offre un environnement exceptionnellement favorable à l'investissement minier, ceci n'est évidemment pas possible. Les résultats d'études de cas indiquent qu'il existe de grandes différences dans l'économie de la mise en valeur de mines et dans le potentiel d'exploration selon la région et la province dans lesquelles sont situés les gisements. On a examiné les raisons de ces disparités et on a constaté qu'elles étaient dues à l'interaction de plusieurs variables clés liées à l'emplacement tels que les taux des salaires, les frais d'énergie, les dispositions concernant les déductions de taxes minières, les différences régionales dans les dégrèvements pour investissements, les taux de l'impôt provincial sur les corporations et plusieurs autres taxes.

En ce qui concerne l'incitation à l'investissement minier, la Nouvelle-Ecosse, le Nouveau-Brunswick, le Québec et la Saskatchewan se placent généralement en tête du peloton canadien. Par contre la Colombie-Britannique vient en queue et est moins bien placée que le reste du pays. Cependant on démontre que l'allégement considérable des

taxes figurant dans le budget 1985 de la Colombie-Britannique réduit de beaucoup l'écart par rapport à d'autres juridictions.

En se servant de la méthodologie présentée dans la communication, on suggère comment effectuer une mise à jour ultérieure de cette évaluation et comment analyser ce problème de politique complexe et important de façon plus complète.

1. INTRODUCTION

Setting

The economic potential of mining may be assessed in a number of ways. One approach, increasingly used for both corporate planning and government policy purposes, is to evaluate the competitive position of an actual or potential mineral producer in the international marketplace relative to other suppliers.

Such examinations of competitive position vary from cost comparisons of breakeven prices for operating mines, through the assessment of medium-term costs associated with developing new mine capacity, to long-term evaluations of the economics of mineral supply from the start of exploration. The complexity of the analysis increases with the scope and timeframe of interest. Many factors are involved. One component of competitive position is the quality of mineral resources. Other key factors include available technology, wage and salary rates, labour productivity, the cost of capital, infrastructure requirements, distances from sources of materials supply and to mineral markets, management attributes, organizational efficiency, government mineral policies (particularly taxation), and inflation and exchange rates. The study fits within this competitive position framework.

The variable economic conditions which exist within Canada have a direct bearing on the viability of mine development and, thereby, on mineral exploration potential. This paper examines locational aspects of competitive position among several Canadian regions and provinces.

Objectives and Scope of Study

The objectives of the study are to:

- formulate an evaluation procedure for examining the effects of location on the economics of developing mineral deposits;

- apply this methodology to two representative mineral deposits in order to illustrate the relative attractiveness of mine development in Nova Scotia, New Brunswick, and Newfoundland within eastern Canada; Quebec, Ontario, Manitoba, and Saskatchewan within the central Canada region; and British Columbia in western Canada.

In so doing, the paper is intended to foster an improved understanding of the variable economic potential associated with mineral exploration and development opportunities, and a more informed basis for corporate planning and government policy formulation.[1]

Our assessment of competitive position concerns two hypothetical mine development opportunities, representing exploration targets of interest: a medium-size open pit tungsten deposit, and a small underground gold deposit. These projects are initially evaluated in eastern Canada; then, in the other two regions; and, more specifically, in each of the eight provinces considered.

The study is restricted to an examination of the effects of location. Differences in the inherent geological quality of mineral resources among regions and provinces are not taken into account. These deposit-specific characteristics are considered for study purposes to be common to all situations and are held constant in our appraisal.

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1. For a fuller description of the work which forms the basis for this paper, the interested reader is referred to the "source study", Effects of Location on Mine Development Potential: Nova Scotia's Competitive Position in Canada, D.W. Davis, B.W. Mackenzie, and M.L. Bilodeau, open file report 621, Nova Scotia Department of Mines and Energy, Halifax, May 1985, 104 pp.

2. EVALUATION PROCEDURE

General Approach

The variables which determine the economics of mine development may be broadly grouped into those which are influenced by deposit location and those which are independent of location. The locational variables may be classified into two categories, according to whether the influence of location arises from:

- regional economic conditions;
- taxation policies.[2]

The non-locational variables, on the other hand, include:

- general economic conditions;
- deposit-specific characteristics.

Thus, we are dealing with four basic evaluation components, two of which are a function of deposit location, and two of which are considered to be independent of location.

The methodology adopted is based on two tenets. First, in order to isolate the effects of deposit location, the non-locational factors should be held constant. Second, in order to understand and explain locational differences, the regional and taxation components should be examined one at a time before appraising their combined impact. This general approach is applied to analyze the effects of location, utilizing the representative tungsten and gold deposit case studies.

Evaluation Components

The evaluation is based on 1985 outlook conditions. All money values are expressed in constant 1985 dollars (Canadian dollars, unless otherwise stated).[3]

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2. The source study considers a third locational component - the site of a deposit within a region in relation to established infrastructure including, in the case of the gold project, economic effects of existing processing facilities. While this component is generally held constant here, the consequences of varying distance from established infrastructure, and the benefits of utilizing existing processing facilities, are illustrated in chapter 4.
3. Discount rates and rates of return are therefore expressed as "real" (as opposed to nominal) rates.

General Economic Conditions

General economic conditions are considered to be independent of deposit location. To evaluate the tungsten and gold mine development opportunities, the following estimates and assumptions are required:

- currently available mining and mineral processing technology;
- expected mineral commodity price projections in U.S. dollars;
- U.S. dollar:Canadian dollar exchange rate;
- weighted average cost-of-capital discount rate;
- general rate of inflation to correctly assess tax allowances and payments.

Deposit-Specific Characteristics

Deposit-specific characteristics are also assumed to be common to all locations and are, therefore, held constant throughout the analysis. In this regard, case study estimates and assumptions are required for ore reserves[4], capacities, production methods, recovery factors, product specifications, preproduction period, employment, and energy consumption.

Regional Economic Conditions

The tungsten and gold mine development opportunities are initially evaluated assuming that they occur at a typical site in eastern Canada. The estimates and results associated with this situation, termed "base case conditions", provide a standard for comparison with other study variants. The two projects are then hypothetically relocated to sites in central Canada, and western Canada. Modifications are made to the cash flow estimates to allow for regional dif-

4. Grades are selected to be realistic in terms of achievable exploration targets. Within possible geological limits, deposit grades are chosen to provide "reasonable" before-tax rates of return for the mining projects in their "base case" eastern Canada location; about 18 percent for the tungsten project and 25 percent in the case of the gold project. For the evaluation of breakeven grades, the grades required to achieve a minimum acceptable economic result are in each case determined.

ferences in wage and salary rates, electrical power charges, topography, working capital requirements, and market locations and distances (in the case of the tungsten project).[5]

Taxation Regimes

The incorporation of taxation into the analysis requires more specific attention to locational effects among individual provinces. The tungsten and gold projects are subjected to the actual Canadian taxation systems existing in January 1985 in Nova Scotia, New Brunswick, and Newfoundland within eastern Canada; Quebec, Ontario, Manitoba, and Saskatchewan within the central Canada region; and British Columbia in western Canada. Five types of taxation payment are included in the analysis: federal corporate income tax, provincial corporate income tax, provincial mining tax, provincial royalty[6], and selected non-profit taxes. The paper assumes that taxation is on an individual project (or "stand-alone") basis. Thus, mining taxation allowances are constrained by the availability of income from the project itself.[7]

The non-profit taxes incorporated in the evaluation, selected on the basis of their perceived importance, are: provincial sales tax, provincial fuel tax, corporation capital tax, workers' compensation payments[8], and property taxes.[9] Non-profit taxes take the form of capital and operating

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5. We assume that the deposit sites in each of the regions are equally-well located with respect to the delivered cost of supplies for construction and production.
6. The distinction between provincial "royalty" and "mining tax" payments made for study purposes is that royalties are levied on gross income or revenue whereas mining tax is based on net income or profit.
7. The source study also considers taxation on an integrated company (or "flow-through") basis. While results illustrate the important tax advantage realized by integrated companies, the competitive rankings among provinces are shown to remain essentially unchanged. See pp. 68-70, source study.
8. Workers' compensation payments, which may be more properly termed a "government mandated cost", are included because of their size, and their variability among provinces.
9. Property taxes have been particularly hard to estimate. It is apparently difficult to make generalizations about property tax burdens within each province.

costs and, generally speaking, are allowable deductions for income and mining tax purposes.10 This somewhat complicates the determination of non-profit taxation effects.

Stages of Analysis

The evaluation components are integrated in various ways for purposes of carrying out the three stages of appraisal.

Regional Economic Consequences

In this first stage, the influence of differences in regional conditions is assessed. General economic conditions and deposit-specific characteristics are initially applied to estimate revenues, capital costs, and operating costs for the representative tungsten and gold projects in eastern Canada. Regional economic differences are then used to modify the eastern Canada revenue and cost estimates to the conditions applicable at the project sites in central and western Canada. In each case, a before-tax time distribution of cash flows is derived from the appropriate revenue, capital cost, and operating cost estimates. Total minesite revenue, net present value, and rate of return are then assessed.

Effects of Taxation

To isolate the consequences of taxation, all other evaluation components are held constant. Thus, the before-tax base case estimates are used throughout this second stage of evaluation and analysis. The taxation systems existing in each of the eight provinces considered are applied in turn to these standard before-tax conditions. The approach adopted may be viewed as theoretical because the before-tax cash flows for these projects actually vary significantly, as we will see, as a function of regional conditions. However, it is only by means of this type of standardization that the consequences of taxation can be detached.

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10. The only exception found is the case of corporation capital tax paid in British Columbia which is not an allowable deduction for provincial mining tax purposes.

In each province, the appropriate taxation regime is applied to the standard before-tax estimates to derive an after-tax time distribution of cash flows for each project. The following economic criteria are then evaluated: after-tax net present value, after-tax rate of return, total undiscounted and discounted tax payments, tax payment components, company and government shares of before-tax value, and tax payments expressed as a proportion of total project costs.

Combined Impact

In the final evaluation stage, the regional and taxation differences evaluated in the first two stages are integrated to assess the combined impact of location on mine development economics. For this purpose, the before-tax eastern Canada base cases are combined in turn with the tax systems in Nova Scotia, New Brunswick, and Newfoundland; the before-tax estimates for the tungsten and gold projects in central Canada are evaluated together with the tax systems existing in Quebec, Ontario, Manitoba, and Saskatchewan; and the taxation regime in British Columbia is applied to the before-tax estimates for western Canada. The after-tax time distribution of cash flows is in each case assessed. After-tax net present values, rates of return, and breakeven ore grades are then evaluated to illustrate the combined impact of regional and taxation conditions.

3. REPRESENTATIVE MINE DEVELOPMENT CASES

General Economic Conditions

Market Estimates

With regard to market price projections, the tungsten mine is assumed to produce combined scheelite - wolframite concentrates, containing tungsten trioxide (WO_3); a high-grade 68 percent WO_3 concentrate, and a low-grade 35 percent WO_3 concentrate.[11] An impure bullion would be recovered from the gold deposit.

Price projections are made to evaluate the time distribution of revenues for each of the mine development opportunities. Since market price is both the most important and the most uncertain variable in the assessment, cash flows are evaluated as a function of price. An expected or mean price outlook is bounded by upper- and lower-limit prices for each commodity as shown in table 1. The timeframe of these price projections is intended to correspond to the productive lives of the tungsten and gold projects being evaluated.[12]

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11. Scheelite (a calcium tungstate) and wolframite (an iron-manganese tungstate) are the most important tungsten ore minerals. The tungsten deposit mineralization is assumed to be composed of a mixture of the two. Tungsten concentrate is processed chemically to produce tungstic acid and/or ammonium paratungstate (APT), from which tungsten metal powder is made. The metal powder is further processed into products such as tungsten carbide and ferrotungsten. An intermediate chemical treatment stage to produce market-grade synthetic scheelite would be required for the low-grade concentrate product.
12. The basic United States dollar price estimates have been combined with exchange rate estimates in the way which gives the widest Canadian dollar price range. The correlation which exists between metal prices and the exchange rate is not considered. This correlation would have the effect of increasing the $US per $C exchange rate as a function of metal price.

Table 1

METAL PRICE PROJECTIONS
(US dollars)

Metal	Price Basis	Lower Limit Prices	Expected Prices	Upper Limit Prices
Gold	per ounce metal	250	350	500
Tungsten	per metric tonne unit of WO_3 in concentrate[a]			
	68% WO_3 concentrate	65	95	130
	35% WO_3 concentrate	49	71	98
Exchange Rate	$US/$C	.90	.80	.75

[a] There are 100 metric tonne units in a metric tonne. Thus, a tonne of concentrate grading 68 percent tungsten trioxide (WO_3) contains 68 metric tonne units of WO_3. A metric tonne unit is equivalent to 22.046 pounds.

The basis for the tungsten price is the content of WO_3 in concentrate delivered to the consumer. A tariff of 17 U.S. cents per pound of tungsten contained is levied on imports into the United States. The transportation cost of delivering concentrate from mine to market is deducted in estimating sales revenue at the minesite. Unit transportation costs, based on container shipment and handling, are estimated to vary from $76 to $167 per wet tonne of concentrate, depending on specified mine and market locations. The concentrate is assumed to contain 5 percent moisture.

The gold price projections pertain to refined metal at the market. A fixed charge of US $10 per ounce is applied to cover the insurance, transportation, refining and marketing costs associated with converting the impure bullion produced at the minesite to refined metal in the ultimate market.

Discount and Inflation Rates

A 10-percent discount rate is selected as our best estimate of the weighted average cost of capital (in constant money terms) for investment in the tungsten and gold mine projects. To analyze the sensitivity of results to the cost of capital, assessments are also made for 5 percent and 15 percent rates.

A riskless discount rate of 3 percent is used to evaluate tax revenues from a government viewpoint. The rationale is that the government as tax collector, not committing investment funds, bears none of the risk associated with the investment.[13]

Inflation reduces the constant-money benefits or credits associated with those tax write-offs which can only be taken over a future period of time. A 5-percent general rate of inflation is assumed in the study to evaluate the effects of taxation.

Deposit-Specific Characteristics

The following specifications are set down with a view to characterizing the geological potential of the tungsten and gold deposits.

An idealized section through the representative tungsten deposit is presented in figure 1. The deposit has been formed by hydrothermal solutions invading the top part of an intrusive granite stock, forming an irregular but extensive greisen zone, exposed on surface, which hosts the scheelite and wolframite mineralization. An average stripping ratio of 1.1 tonnes of waste per tonne of ore extracted would be associated with open pit mining of the

13. This is an admittedly contentious point. The public sector often provides funds for infrastructure related to mineral development. Also, when a mine closes, public outlays are frequently incurred. Another argument is that the opportunity cost of government tax revenues is the foregone return to private investment. Both of these views support discounting tax payments at the cost of capital rate rather than the riskless rate. In fact, the source study and the summary results presented here evaluate tax revenues in three ways: on an undiscounted basis, discounted at the 3-percent risk-free rate, and discounted at the 10-percent cost-of-capital rate.

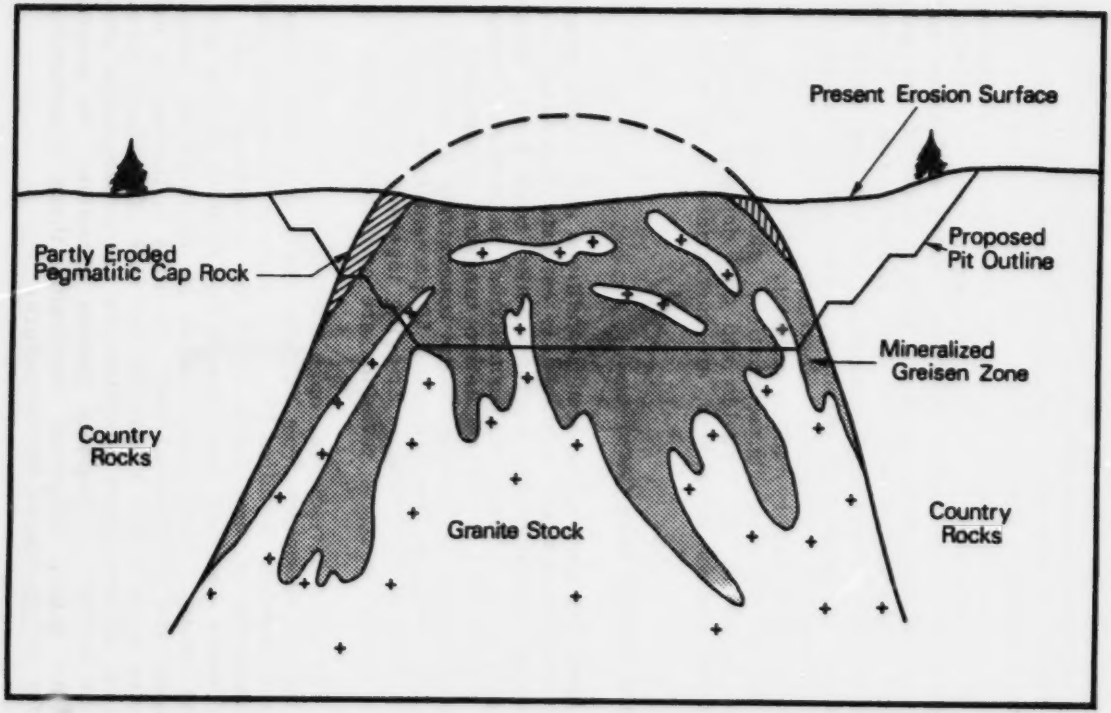

Figure 1. Idealized Section through Representative Tungsten Deposit

deposit. The tungsten ore is amenable to processing by crushing, grinding, and gravity separation to produce a high-grade 68-percent WO_3 concentrate, achieving a 65-percent recovery of contained tungsten. Magnetic separation and flotation are used to increase recovery by 20 percent, producing a low-grade 35-percent WO_3 concentrate.

Figure 2 provides a schematic isometric projection of the representative gold deposit. The deposit is found in a thick sequence of folded quartzites and slates. Mineralization is structurally controlled, occurring as "en echelon" quartz veins within shoots which are related to flexures and fractures in the limbs of major folds. Some of the gold content is associated with sulphide mineralization. Mining would be by underground methods. The gold ore would be processed by crushing, grinding, cyanidation, carbon-in-pulp adsorption, stripping, electrowinning, and smelting, resulting in an impure bullion product.

Deposit-specific characteristics, reflecting the geological nature of the tungsten and gold deposits in relation to current outlook conditions, are summarized in table 2.

Eastern Canada Base Cases

The foregoing general economic conditions and deposit-specific characteristics are combined to estimate revenues, preproduction capital costs, and production costs for tungsten and gold project "base case conditions" in eastern Canada. With respect to the representative tungsten opportunity, it is assumed that 50 percent of the concentrate is shipped to European smelters, the remaining 50 percent being marketed in the state of New York. Bringing together relevant estimates, annual minesite revenues are estimated as shown in table 3.

The mine development opportunities are assumed to be situated 10 kilometres from existing road, powerline, housing and townsite facilities.[14] It is further considered that 10 kilometres of new roads would be constructed, and a 10-kilometre electrical transmission line built to service each of the mines. New houses would be required for senior managers and professional staff; 10 units in the case of the tungsten project and 3 units in the case of the gold mine. Identical infrastructure specifications are subsequently used for the central and western Canada minesites. We assume that the mining companies developing these opportunities pay for the associated infrastructure.

14. The tungsten deposit is hypothetically situated 85 kilometres west of Halifax. The gold deposit is located northeast of Halifax in the Caribou gold district.

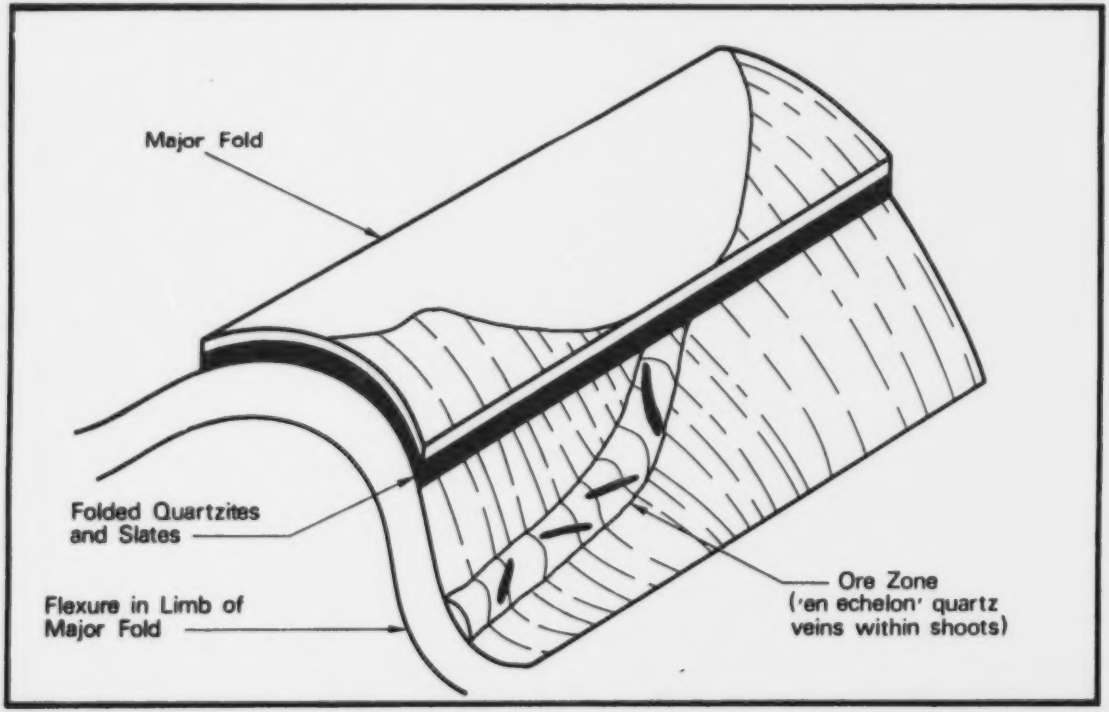

Figure 2. Schematic Isometric Projection of Representative Gold Deposit

Table 2

DEPOSIT-SPECIFIC CHARACTERISTICS

Characteristic	Deposit	
	Tungsten	Gold
Recoverable ore reserves[a]:		
Size (tonnes)	63,000,000	650,000
Grade	0.170% WO_3	9.40 gpt Au
Capacity (tonnes of ore per year)	3,500,000	65,000
Mining method	open pit	irregular open stoping
Preproduction period (years)	2	2
Employment during construction (person-hours, excluding infrastructure)	742,000	216,000
Employment during production (persons)	265	80
Electrical power consumption (million kilowatt-hours per year)	93.75	5.18
Fuel consumption (million litres per year)	1.5	-

[a] while the specified ore reserves represent reasonable exploration and development targets, deposits of these types being characteristically varied, there are no "typical" ore reserve parameters.

Table 3

ANNUAL REVENUE ESTIMATES: EASTERN CANADA BASE CASES
($ thousand)

Price Variant	Tungsten Project	Gold Project
Lower-limit prices	32,638	4,977
Expected prices	54,680	7,931
Upper-limit prices	80,598	12,192

Preproduction capital costs are estimated to total $133.5 million for the tungsten mine development and $11.2 million for the gold project. Table 4 presents percentage breakdowns of these requirements.[15] Annual production costs, including operating costs and sustaining capital requirements, are assessed at $26.6 million and $4.4 million for the tungsten and gold mines respectively. Percentage breakdowns of these costs by stage and factor of production are shown in table 5.[16] The evaluation is based on 100-percent utilization rates.

Regional Economic Differences

The eastern Canada base case conditions are now modified for regional economic characteristics in order to derive estimates for the minesites in central and western Canada. These adjustments are based on differential wage and salary rates, topographic conditions, electrical power charge schedules, and, in the case of the tungsten project, concentrate market locations. Working capital requirements, assumed to provide for three months' operating costs, are adjusted accordingly.

Wage and Salary Rates

Wage and salary rate differentials are based on Statistics Canada data for average hourly earnings of salaried and hourly employees. The construction industry series is applied to labour costs incurred during mine development while mining industry data are used for employment during production.[17]

The rates assumed for the eastern Canada base cases are an average of Nova Scotia and New Brunswick statistics. For study purposes, it was considered realistic to

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15. For the calculation of non-profit taxes, further breakdowns are required for building materials and production equipment. Details are given in the source study.
16. Further annual breakdowns of sustaining capital and mining supplies are required for tax purposes. Details may be found in the source study.
17. The statistical data utilized and the averaging process employed are detailed in appendix A (pp. 81-86) of the source study.

Table 4

PREPRODUCTION CAPITAL COST BREAKDOWNS: EASTERN CANADA BASE CASES
(percent)

Category	Tungsten Project	Gold Project
Mine development	0.3	20.1
Mine plant and machinery	6.0	22.2
Mill facilities	76.0	29.7
Powerline	0.3	1.4
Road	0.9	6.3
Housing	0.6	2.3
Design and construction management	11.1	8.6
Working capital	4.8	9.4
Total	100.0	100.0

Table 5

PRODUCTION COST BREAKDOWNS: EASTERN CANADA BASE CASES
(percent)

Production Stage	Factor Input					
	Labour	Supplies[a]	Fuel	Power	Other	Total
Tungsten Project:						
Mining	10.6	15.1	2.4	-	-	28.1
Milling	20.1	23.0	0.4	13.4	-	56.9
General and administration	6.8	2.2	-	2.7	3.3	15.0
Total	37.5	40.3	2.8	16.1	3.3	100.0
Gold Project:						
Mining	45.4	14.3	-	2.4	-	62.1
Milling	12.7	8.9	-	4.0	-	25.6
General and administration	6.9	0.8	-	-	4.6	12.3
Total	65.0	24.0	-	6.4	4.6	100.0

[a] includes operating costs and sustaining capital.

adjust the Nova Scotia wage rates, which are strongly influenced by coal mining, upwards towards the New Brunswick statistics which are more characteristic of metal mining. Wage rates for central Canada represent averages for Quebec, Ontario, and Manitoba. The western Canada wage rates are based on statistics for British Columbia. The resulting weighted average wage and salary rate differentials, relative to estimated eastern Canada conditions, are as follows.

Mine development:
Central Canada +20 percent;
Western Canada +55 percent.

Mine production:
Central Canada +9 percent;
Western Canada +26 percent.

We can find no evidence that these regional wage rate differentials are attributable to variations in labour productivity. Consequently, the wage rate adjustments are considered to represent real cost differences.[18]

Unit Infrastructure Costs

The labour components of road, transmission line, and housing and townsite costs are adjusted for the regional

18. What, then, explains the striking wage and salary rate variations among regions? These differences result from the interaction of several factors including the regional labour environment, living costs, worker expectations, union militancy, tradition, labour competition, and alternative employment opportunities. For example, relatively high wage rates have always existed in British Columbia. Initially, this may have represented a "remote area" premium to attract the required workforce. More recently, high wages in the construction industry are mainly the result of provincial certification and strong union power in controlling the number of new entrants. In British Columbia's mining industry, high wage rates, which appear to have been maintained through a particularly severe mining recession, are partly due to the premiums paid in competing labour markets - the forest products industry, and the energy sector in Alberta. In any case, the regional differences assessed are substantial.

wage and salary rate differentials.[19] In western Canada, it is further assumed that the unit costs for road and power-line construction would typically be 50 percent higher than in eastern and central Canada due to more severe topographic conditions.

Electrical Power Charges

Regional power cost estimates are based on 1984 provincial rate schedules viewed in relation to the loading and demand requirements of the tungsten and gold projects. Base case charges assume Nova Scotia rates; power costs in central Canada represent a composite of Ontario and Manitoba rates; and estimates for western Canada again reflect the situation in British Columbia. Thus, the following power cost differentials are estimated and applied relative to eastern Canada base case conditions.

Central Canada:
- Tungsten mine -41 percent;
- Gold mine -36 percent.

Western Canada:
- Tungsten mine -34 percent;
- Gold mine -25 percent.

Tungsten Concentrate Market Locations

Central Canada: 50 percent of the high-grade and low-grade concentrates would be shipped to smelters in Pennsylvania, the remaining 50 percent being sold in Ohio.

Western Canada: 50 percent of the high-grade and low-grade concentrates would be marketed in California, the remaining 50 percent being shipped to Japan.

Regional Cash Flow Adjustments

Regional concentrate market specifications are combined with unit transportation cost estimates to derive annual revenues for the tungsten mine in central Canada and western Canada. Annual revenue estimates for the gold project are unaffected by deposit location.

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19. The labour components of these infrastructure costs are estimated to be 20 percent, 20 percent, and 30 percent respectively.

With regard to cost estimates, the following adjustments for regional economic conditions are made relative to the eastern Canada base cases:

- construction industry wage rate differentials are applied to the projected employment during mine development, preproduction mine and mill capital costs being adjusted accordingly;

- construction industry wage rate differentials and differences in topographic conditions are employed to adapt the infrastructure costs;

- mining industry wage rate differentials are used to modify the labour component of production costs;

- power cost differentials are applied to adjust production costs;

- working capital requirements, equivalent to three months' operating costs, are modified to suit overall changes in production costs.

The resulting revenue, preproduction capital, and production cost adjustments for central and western Canada, relative to eastern Canada base case conditions, are detailed in table 6. Regional totals are summarized in table 7.

Taxation Regimes

Based on the foregoing estimates for the assessment of before-tax cash flows, the direct effects of taxation on the tungsten and gold projects are evaluated. Thus, the tax systems existing in Canada at the beginning of 1985 are imposed to measure the after-tax incentive for investment, and the level, structure and incidence of tax payments.[20] The tax systems applied are described in the source

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20. Effects of mining tax changes announced in Quebec and Ontario during 1985, the February 1986 federal budget, and proposed mining tax changes in Saskatchewan are not considered. While the reduction in non-profit taxes introduced in the March 1985 British Columbia Budget are not generally included, the effects of these changes are examined in chapter 5.

Table 6

REGIONAL DIFFERENCES RELATIVE TO EASTERN CANADA BASE CASES
($ thousand)

Cost Component	Tungsten Project		Gold Project	
	Central Canada	Western Canada	Central Canada	Western Canada
Annual minesite revenue:				
Lower-limit prices	-710	-305	-	-
Expected prices	-815	-306	-	-
Upper-limit prices	-877	-305	-	-
Annual production cost:				
Wages and salaries	+897	+2,591	+257	+745
Electrical power	-1,754	-1,455	-102	-70
Preproduction capital cost:				
Wages and salaries	+2,420	+6,655	+687	+1,890
Infrastructure	+100	+1,410	+45	+659
Working capital	+86	+584	+88	+218

Table 7

TOTAL PROJECT REVENUES AND COSTS BY REGION
($ thousand)

Region	Annual Minesite Revenue			Annual Production Cost	Pre-Production Capital Cost
	Lower-Limit Prices	Expected Prices	Upper-Limit Prices		
Tungsten project:					
Eastern Canada	32,638	54,680	80,598	26,573	133,477
Central Canada	31,928	53,865	79,721	25,716	136,083
Western Canada	32,333	54,374	80,293	27,709	142,126
Gold project:					
Eastern Canada	4,977	7,931	12,192	4,410	11,199
Central Canada	4,977	7,931	12,192	4,565	12,019
Western Canada	4,977	7,931	12,192	5,085	13,966

study.[21] A brief synopis follows of the non-profit taxes considered since these represent a somewhat novel feature of the evaluation.

Provincial Sales Tax

Provincial sales tax may be levied on the purchase price of building materials during the construction period, capital expenditures for production equipment and machinery, and the purchase of materials and supplies consumed in the production process. The rates applicable to mining vary, from 12 percent on mine production materials in Newfoundland, to tax exemptions on mine production machinery and materials in Quebec and Ontario.

Provincial Fuel Tax

Provincial fuel tax is considered for the tungsten mine, based on diesel fuel consumption for open pit equipment. For mining operations, the applicable fuel tax rates at the beginning of 1985 ranged from 12.2 cents per litre in Newfoundland, to tax exemptions in New Brunswick, Quebec, Ontario, and Saskatchewan (which has no diesel fuel tax).

Corporation Capital Tax

The corporation capital tax base consists of equity capital, debt capital, and retained earnings, less depreciation as allowable for provincial corporate income tax purposes. This tax - operative in Quebec, Ontario, Manitoba, Saskatchewan, and British Columbia - is levied from the time capital is expended. The annual rates applied to the capital base vary from 0.45 percent in Quebec to 0.20 percent in Manitoba and British Columbia.

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21. See pp. 28-38 and appendix B (pp.87-103) of the source study. Originally, a 10-percent investment tax credit rate was applied for income tax purposes in Nova Scotia, New Brunswick, and Newfoundland. Results have been revised here to take account of the 20-percent rate of tax credit which actually applies in the maritimes.

Workers' Compensation Payments

This government-mandated cost provides each province with a fund for the payment of compensation and other accident costs to industrial workers. Assessment rates, expressed as a premium paid per year per $100 of total payroll, are set each year for various industry categories, including several mining classes. Rates apply up to a specified maximum payroll limit per worker.

For study purposes, 1985 workers' compensation rates have been selected in each province for mine classifications which most closely fit the two mines being evaluated. Assessment premiums for the open pit tungsten mine vary from $0.90 per $100 of total payroll in Saskatchewan to $8.82 per $100 in British Columbia. For the underground gold mine, assessment rates vary from $1.90 per $100 of total payroll in New Brunswick to $12.05 per $100 in Ontario. The maximum total payroll applicable per employee per year varies from $19,000 in Nova Scotia to $45,500 in Newfoundland.

The wide variations in workers' compensation payments which are shown to exist among provinces suggest that there may be something arbitrary and inequitable with the ways rate schedules are established.

Property Taxes

Property taxes include provincial, regional, and municipal levies on the assessed value of land, buildings, machinery and equipment. School, hospital, electoral, business, water, and other taxes are covered in this category.

Property taxes are particularly difficult to estimate for a number of reasons. The determination of "assessed value" is usually complex, arbitrary, and dynamic. The definition of assessed value is often different for the various property tax components. Assessment rates may be a function of the area in which a mine is located and, in particular, may depend on whether the minesite is situated in a municipality. In some cases, generally applicable rates may be replaced by ad hoc provincial agreements. Thus, the calculation of property taxes is difficult, and it is hard to make provincial generalizations regarding typical payments.

The study uses two approaches for the evaluation of property taxes within each province. First, "assessed values" for the tungsten and gold mines are estimated using simplifying assumptions with regard to provincial regulations. The appropriate property tax rates are then applied

to these valuations to determine the annual property taxes payable.[22] Second, a partial survey has been made of actual property taxes paid in various provinces by operating mines of similar type and scale to the two case studies. Our study estimates attempt to reconcile the results of these approaches.

Summing Up

These five non-profit tax components are initially estimated by province assuming before-tax base case conditions. Then, similar appraisals are projected for the central and western Canada situations.[23]

Estimates for eastern Canada base case conditions are illustrated in figures 3 and 4, showing provincial variations in the level and components of total undiscounted non-profit taxes over the lives of the two projects. Clearly, non-profit taxes are not only sizeable, but also highly variable among provinces. For the tungsten project, non-profit tax payments vary from $16.1 million in Quebec to $75.5 million in British Columbia. Sales tax and property tax generally appear to be the largest components. Non-profit taxes for

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22. As mentioned, within-province variations depend in part on whether a mine is located in a municipality. This distinction is particularly critical in Ontario. In view of our assumption that the tungsten and gold deposits are sited 10 kilometres from established infrastructure, it is assumed here, for purposes of estimating property tax, that the mines would operate within municipal boundaries. The source study also considers less-accessible minesite variants situated outside municipalities.

23. A number of improvements could be made to the non-profit tax estimates including the incorporation of federal sales tax, and provincial sales tax on the purchase of electrical power (in Manitoba, Saskatchewan, and British Columbia), and more reliable estimates of property taxes, utilizing a realistic range of possible payments for each provincial situation.

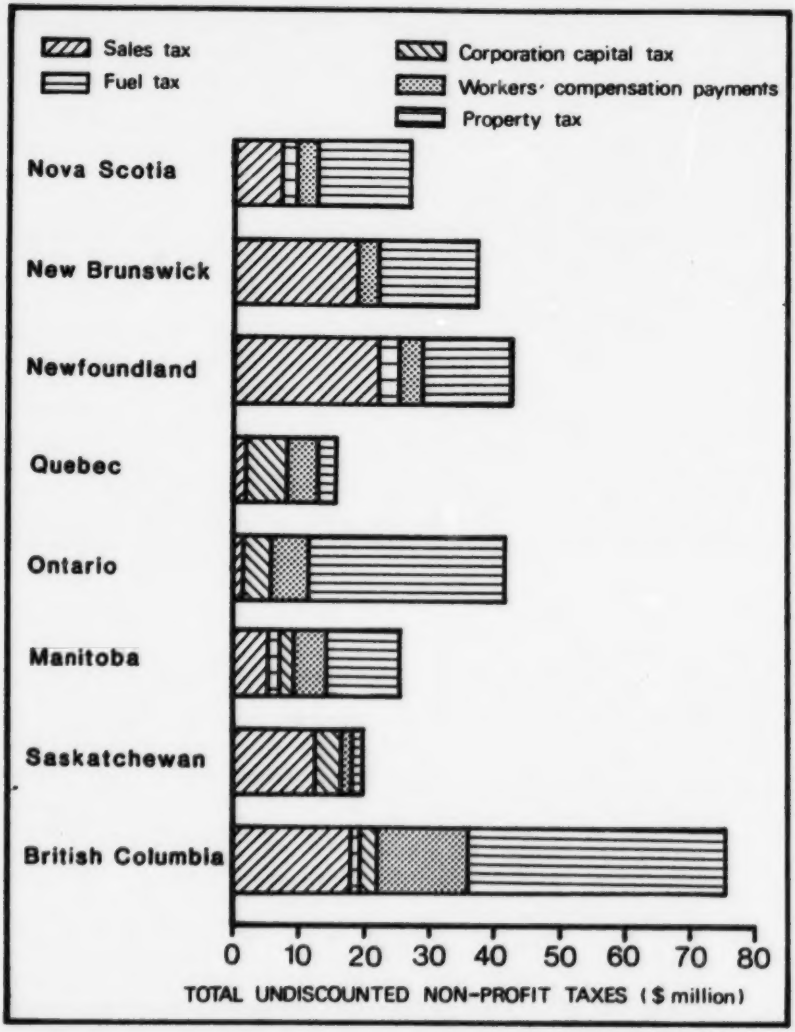

Figure 3. Total Non-Profit Tax Payments and Components: Tungsten Project, Eastern Canada Base Case Conditions

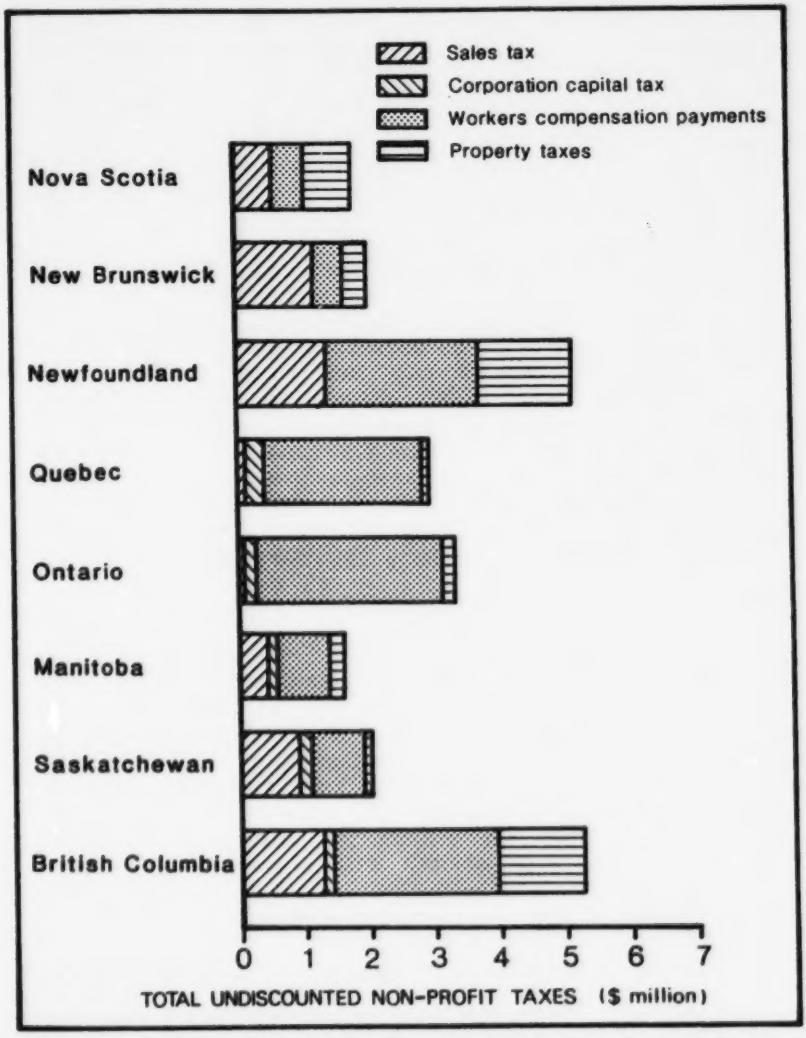

Figure 4. Total Non-Profit Tax Payments and Components: Gold Project, Eastern Canada Base Case Conditions

the gold project range from $1.6 million in Manitoba to $5.3 million in British Columbia, sales tax and workers' compensation assessments being the dominant constituents.[24]

24. Part of these non-profit tax levies no doubt represent payments for "services". For example, if there were no workers' compensation scheme, to what extent would wage rates have to be higher? If no one paid sales tax, could government provide health and education services as they do now? If not, would wage rates, fringe benefits for health premiums, and training costs rise? It would be interesting to consider the off-setting "service" component of the non-profit taxes and the resulting effect on "net" tax payments.

4. REGIONAL ECONOMIC CONSEQUENCES

In this first stage of evaluation, the regional effects of location are analyzed on a before-tax basis. The before-tax economic indicators reflect the productive capability of the tungsten and gold deposits and represent what is available for sharing between company and government prior to taxation considerations.

Eastern Canada Base Case Conditions

Base case conditions for the two projects include a 10-percent cost of capital and expected market price projections. The resulting cash flow distributions are illustrated in figure 5. The net present values at 10 percent, derived from these distributions, are $75.9 million for the tungsten mine development and $8.5 million for the gold mine opportunity. The project rates of return are 18.5 percent and 25.5 percent respectively. Under these circumstances, both mine development opportunities are shown to be economically viable, offering reasonable prospects for wealth creation.

Regional Variants

The tungsten and gold deposits are now hypothetically relocated to sites in central and western Canada. General economic conditions and deposit-specific characteristics are held constant. Modifications are made to the revenue, capital cost, and operating cost estimates (as summarized in tables 6 and 7) to allow for differences in regional economic conditions. Results for central and western Canada are compared with the eastern Canada base case indicators in table 8.

For the tungsten opportunity, the variation in total minesite revenue among regions reflects differences in assumed market locations, unit transportation costs, and tariff payments. The tungsten project situated in central Canada is found to be marginally less attractive than the eastern Canada base case. Thus, the lower sales revenue realized and higher wage and salary rates incurred more than outweigh the region's power cost advantage. Significantly less favourable economic results for the western Canada location are mainly attributable to the significant wage and salary rate premiums which would have to be paid for mine construction and operation.

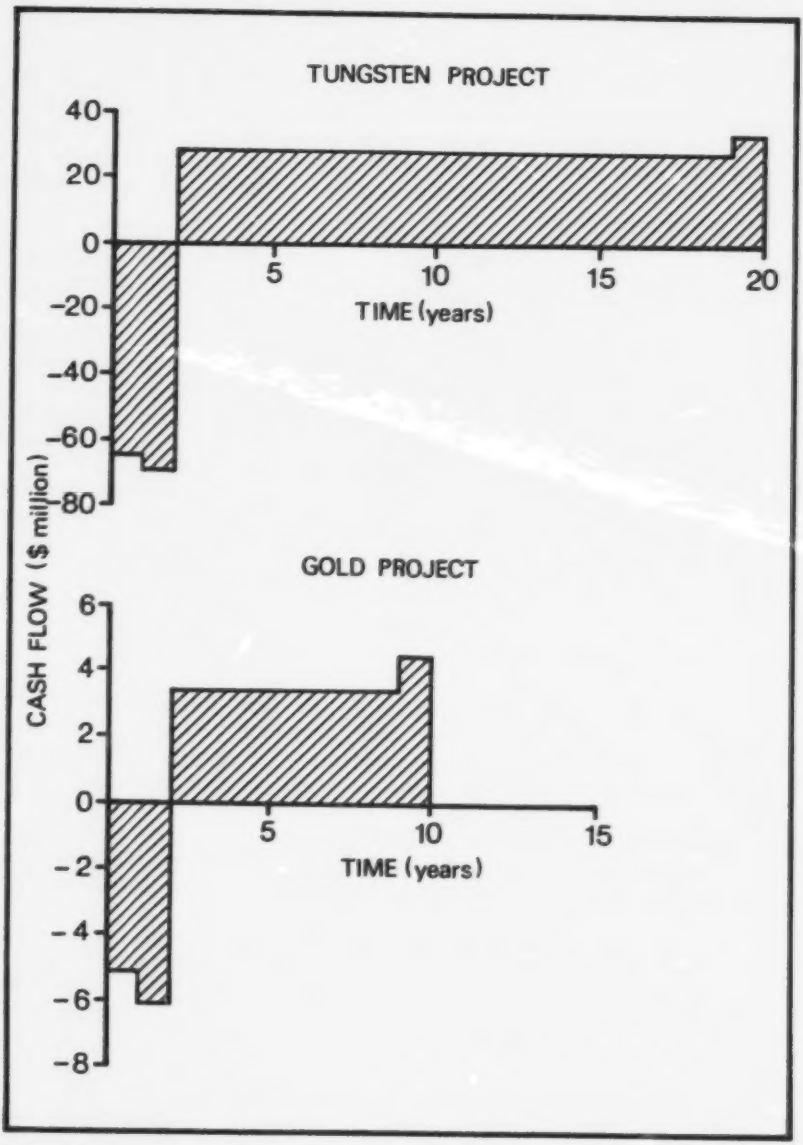

Figure 5. Before-Tax Cash Flow Distributions: Eastern Canada Base Case Conditions

Table 8

BEFORE-TAX ECONOMIC INDICATORS BY REGION

Region	Total Revenue ($ million)	Undiscounted Cash Flow ($ million)	Net Present Value at 10% ($ million)	Rate of Return (percent)
Tungsten project:				
Eastern Canada	984.2	378.7	75.9	18.5
Central Canada	969.6	377.3	74.0	18.1
Western Canada	978.7	345.0	58.8	16.3
Gold deposit:				
Eastern Canada	79.3	25.1	8.5	25.5
Central Canada	79.3	22.8	7.1	22.3
Western Canada	79.3	15.8	2.8	14.5

The general pattern of gold project results shown in table 8 is similar to those found for the tungsten project but the regional differences are more substantial. The labour-intensive nature of the small underground gold mine and the regional wage and salary rate variations, combine to increase the relative attractiveness of the eastern Canada base case. The difference between the eastern and western Canada locations is particularly striking.

Sensitivity of Results to the Cost of Capital

A constant money cost of capital of 10 percent has been used in the evaluations to this point. To analyze the sensitivity of results to this assumption, the before-tax net present values of the two projects are also evaluated for 5 percent and 15 percent rates. Net present values for base case conditions and regional variants are compared in figure 6.

Increasing the cost of capital is shown to have a strong effect on reducing the net present value of these opportunities. For eastern Canada base case conditions, net present values are reduced from $176 million to $23 million, and from $15 million to $5 million, for the tungsten and gold projects respectively, as the discount rate is raised from 5 percent to 15 percent. The viability of the tungsten project is somewhat more sensitive than the gold case to the cost of capital because of the stronger discounting effects on positive cash flows generated over a longer estimated mine life.

Relative differences in project values among regions appear to be maintained throughout. The gold project in western Canada would be uneconomic at the 15 percent discount rate.

Sensitivity of Results to Market Price Variants

The metal price projections used in the foregoing assessments represent uncertain "expected value" estimates. The sensitivity of before-tax net present values to possible variations in market prices within the lower-limit to upper-limit range (table 1) is illustrated in figure 7.

These results clearly show the high degree of sensitivity of mine development economics to future metal price conditions. The tungsten and gold projects would be decidedly uneconomic throughout Canada at lower-limit prices. As market price levels increase, there is a drama-

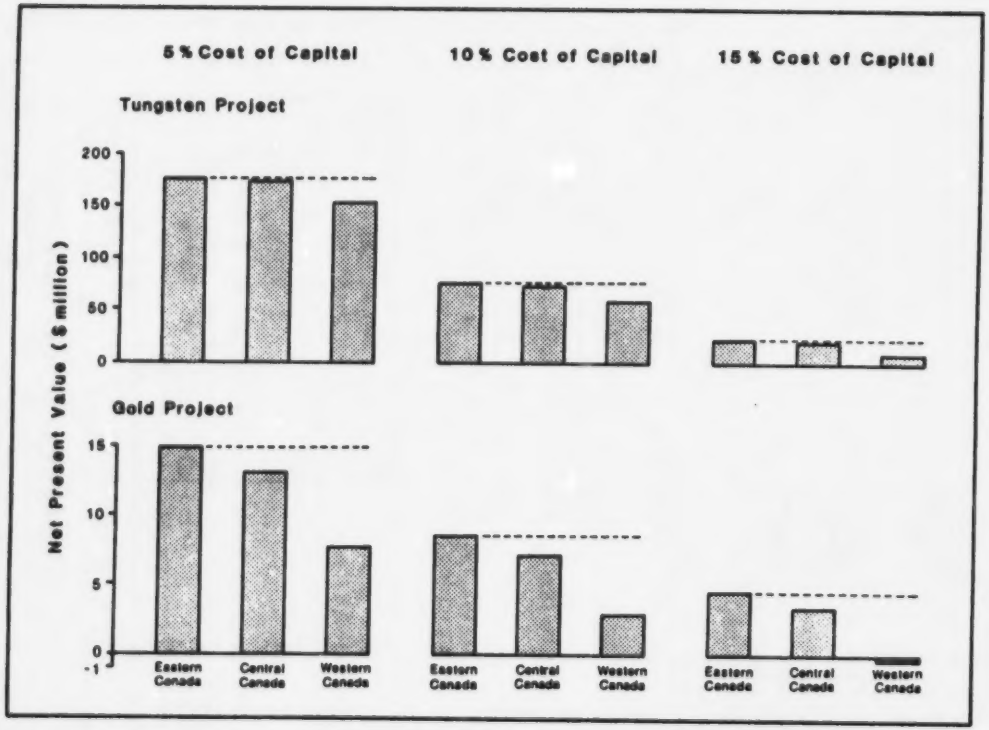

Figure 6. Sensitivity of Before-Tax Net Present Values to the Cost of Capital

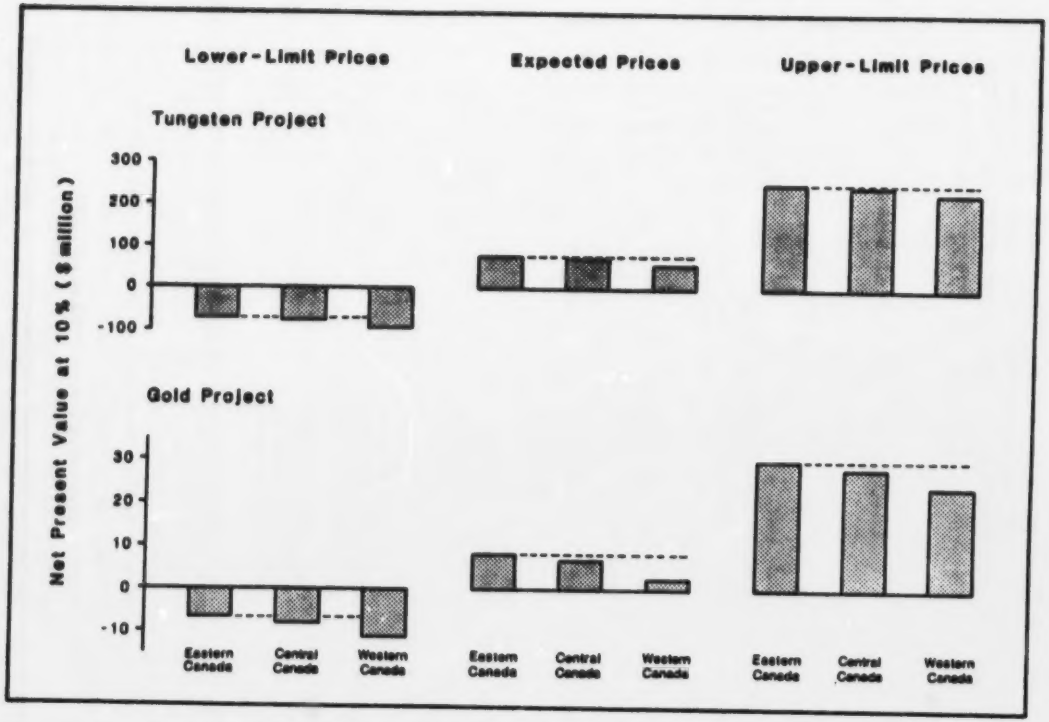

Figure 7. Sensitivity of Before-Tax Net Present Values to Metal Price Variants

tic improvement in the economics of mine development. Both opportunities would be reasonably attractive at expected prices and, at upper-limit prices, would create substantial amounts of new wealth. Relative differences in project values among regions are maintained through the range of metal prices examined.

Less-Accessible Minesite Variant

Within the central Canada and western Canada regions, the tungsten and gold projects are also evaluated at less-accessible sites.[25] For illustrative purposes, the assumption is made that the less-accessible deposits are situated 50 kilometres rather than 10 kilometres from established road, transmission line, housing and townsite facilities. Daily bus commuting of the workforce from an existing townsite is considered. The regional cost estimates for the more-accessible minesites are modified to allow for:

- 40 additional kilometres of road construction;
- 40 additional kilometres of powerline;
- 5 more houses in the case of the tungsten project and 2 more houses for the gold mine;
- the direct cost of providing bus service for daily commuting estimated at $278,000 per year for the tungsten mine and $106,000 per year for the gold operation;
- 50 percent of the wage and salary cost associated with employee commuting time, assumed to total 2 hours per shift. Thus, based on a normal 8-hour shift, the time cost of daily commuting represents a 12.5-percent premium on the payroll cost at the more-accessible sites;

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25. An appraisal of less-accessible sites in eastern Canada was not made because it was considered likely that projects would be close to existing infrastructure. While this may be a reasonable assumption in Nova Scotia and, perhaps, New Brunswick, it is not typical of Newfoundland. The Chetwynd gold project, located near the southern Newfoundland coast, approximately 80 kilometres east of Port aux Basques, provides a current example of remote mining conditions in eastern Canada. Thus, further work on this topic should consider less-accessible minesite variants right across the country.

- associated increase in working capital requirements to provide the equivalent of three months' operating costs.

The resulting capital and production cost adjustments and comparative total project costs are given in the source study.[26] Appropriate modifications are made to the cash flow estimates and the mine development opportunities are re-evaluated. Results are compared with those previously shown for the more-accessible minesites in eastern, central, and western Canada.

Economic indicators for the tungsten project are presented in table 9. The higher infrastructure and commuting costs associated with the less-accessible sites significantly reduce before-tax viability. The difference between sites within central and western Canada appear to be of the same order.

Table 10 shows the before-tax economic indicators for the gold project. The effects of deposit accessibility are more substantial due to the relatively small and labour-intensive nature of the project. Economic differences between sites in western Canada are shown to be greater than in central Canada.

More-accessible deposit situations in eastern Canada may be regarded as typical. However, even the less-accessible sites assumed in central Canada and western Canada may be considered favourable in relation to the low density of infrastructure existing in some areas. This argument, viewed in the context of results presented in tables 9-10, tends to reinforce the before-tax favourability of an eastern Canada location for mineral exploration and development.

Utilization of Existing Processing Facilities

To this point, the evaluation has assumed that a separate new processing facility is required to treat the tungsten and gold ores. We now consider the economic consequences of utilizing an existing processing facility for the small gold deposit at the more-accessible sites. For this variant, a 500,000-tonne per year capacity is assumed for the existing mill, 15 kilometres distant from the small deposit. The capital and production cost estimates for the gold project are first reduced by the small mill costs. Then, the gold

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26. See tables 8-9, p. 27.

Table 9

SENSITIVITY OF BEFORE-TAX ECONOMIC INDICATORS FOR TUNGSTEN PROJECT TO ACCESSIBILITY OF DEPOSIT SITE

	Undiscounted Cash Flow ($ million)	Net Present Value at 10% ($ million)	Rate of Return (percent)
Eastern Canada	378.7	75.9	18.5
Central Canada:			
More-accessible site	377.3	74.0	18.1
Less-accessible site	340.7	56.5	16.0
Western Canada:			
More-accessible site	345.0	58.8	16.3
Less-accessible site	299.7	35.6	13.6

Table 10

SENSITIVITY OF BEFORE-TAX ECONOMIC INDICATORS FOR GOLD PROJECT TO ACCESSIBILITY OF DEPOSIT SITE

	Undiscounted Cash Flow ($ million)	Net Present Value at 10% ($ million)	Rate of Return (percent)
Eastern Canada	25.1	8.5	25.5
Central Canada:			
More-accessible site	22.8	7.1	22.3
Less-accessible site	14.1	1.3	11.8
Western Canada:			
More-accessible site	15.8	2.8	14.5
Less-accessible site	4.1	-5.4	3.1

project is allocated a proportion of the capital costs for the existing concentrating plant based on relative capacities, and the average unit production cost associated with the larger-scale plant. The distance is used to compute a road haulage cost for transporting the ore from mine to mill.

The economic effects of the availability of an existing regional gold mill are presented in table 11. The regional processing opportunity is shown to have a strong impact on improving the economic attractiveness of the gold project.

Table 11

EFFECT OF EXISTING PROCESSING FACILITY ON BEFORE-TAX ECONOMIC INDICATORS FOR GOLD DEPOSIT AT MORE-ACCESSIBLE SITES

	Undiscounted Cash Flow ($ million)	Net Present Value at 10% ($ million)	Rate of Return (percent)
Eastern Canada:			
Separate mill	25.1	8.5	25.5
Regional mill	31.1	12.2	33.9
Central Canada:			
Separate mill	22.8	7.1	22.3
Regional mill	29.5	11.1	31.0
Western Canada:			
Separate mill	15.8	2.8	14.5
Regional mill	24.5	8.0	24.2

Breakeven Ore Grades

Finally, the before-tax effects of location are expressed in another way. Instead of assuming a deposit grade and determining various economic indicators, a minimum acceptable economic result is specified (generally, a 10-percent rate of return) and the breakeven ore grade yielding the required return is assessed. This type of determination is often applied to help screen exploration targets.

Breakeven recoverable tungsten and gold grades for the range of variants considered in this chapter are presented in table 12. The before-tax breakeven ore grades are shown to vary widely, paralleling the differences in economic indicators presented earlier. For example, in the case of the gold deposit, the grade required to yield a 10-percent rate of return varies from 7.4 grams per tonne in eastern Canada to 10.7 grams per tonne at the less-accessible minesite in western Canada. In eastern Canada, the minimum acceptable grade increases from 4.8 grams per tonne at upper-limit prices to 11.8 grams per tonne at lower-limit prices.

Table 12

BEFORE-TAX BREAKEVEN ORE GRADES

	Tungsten Deposit (percent WO_3)	Gold Deposit (grams Au per tonne)
Eastern Canada base case	.135	7.41
Cost-of-capital variants:		
5 percent	.118	6.89
15 percent	.155	7.99
Metal price variants:		
Lower limit	.226	11.80
Upper limit	.092	4.82
Regional variants:		
Central Canada	.136	7.75
Western Canada	.143	8.75
Less-accessible deposit sites:		
Central Canada	.144	9.11
Western Canada	.154	10.66
Regional mill opportunity (gold project only):		
Eastern Canada	-	6.56
Central Canada	-	6.81
Western Canada	-	7.52

5. EFFECTS OF TAXATION AMONG PROVINCES

In order to compare the economic effects of taxation among provinces, all before-tax conditions are held constant, the eastern Canada base cases providing a common standard. Thus, differences in after-tax results solely reflect differences in tax policies as applied to the two case studies.

After-Tax Investment Incentive

The after-tax investment incentive to mining companies is measured here by after-tax net present value and rate of return indicators. The higher these after-tax economic indicators, the greater will be the motivation to invest. A positive investment incentive is considered to exist as long as the after-tax net present value remains positive or, in other words, as long as the after-tax rate of return on investment exceeds the cost of capital.[27]

To illustrate the derivation of after-tax economic indicators, the effect of the Nova Scotia tax regime on the time distribution of cash flows for the tungsten and gold projects is shown in figure 8. The level of tax payments increases from the earlier to later years of mine production. Tax relief in the initial years is attributable to the 20-percent investment tax credit for income tax, and the accelerated write-off of capital for both income and Nova Scotia mining tax purposes. Non-profit taxes, net of income and mining tax credits, are shown in these cases to be quite modest.

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27. Using these investment criteria, contradictory results may arise in the ranking of provinces whereby a project in one province may yield a higher after-tax net present value but a lower after-tax rate of return than in another province. Such contradictions occur because of the difference in time value embodied in the two criteria which discount cash flows at the cost of capital rate and at the rate of return respectively. For projects which are economic after tax, a taxation regime which results in a higher after-tax net present value but a lower after-tax rate of return than another jurisdiction embodies a time distribution of tax payments which is more strongly weighted towards the earlier years of project life.

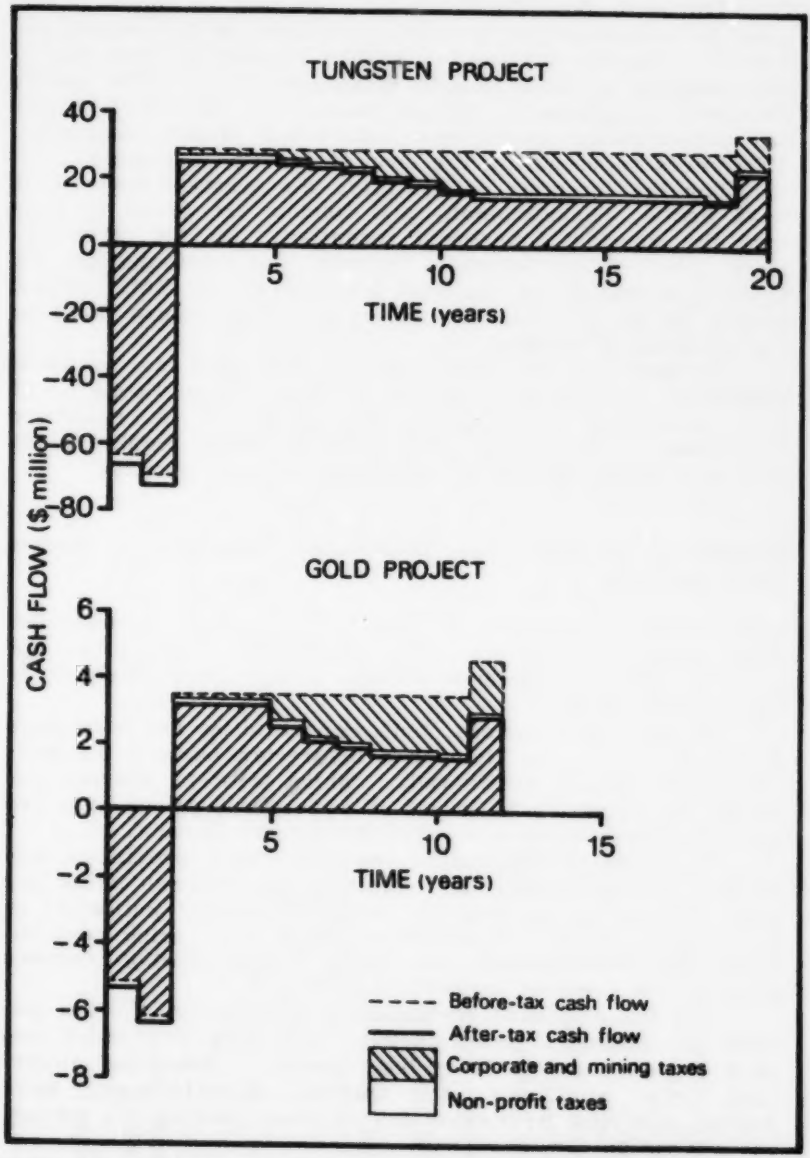

Figure 8. After-Tax Cash Flow Distributions: Base Case Conditions, Nova Scotia Taxation Regime

The cash flow distributions presented in figure 8 are used to determine the after-tax measures of investment incentive. Results for the tax system existing in Nova Scotia are compared in table 13 with indicators for the other seven provinces considered. In all cases, the after-tax values are substantially lower than before-tax project measures, differences representing the level of taxation payments.

For the tungsten opportunity, the taxation systems in Nova Scotia, Saskatchewan, and Quebec are found to provide the greatest investment incentive. At the other extreme, the British Columbia, Ontario, and Newfoundland tax systems appear to be the least favourable. In fact, the tax system in British Columbia drives after-tax values down to the investment margin.

Considering the gold project, the after-tax economic indicators associated with the Quebec, Nova Scotia, and New Brunswick tax regimes are shown to be relatively favourable. Once again, the taxation policies applicable in British Columbia stand out as being the most punitive.

Sensitivity of After-Tax Investment Incentive to Market Price Variants

The results presented in table 13 are based on expected metal price projections. The sensitivity of after tax net present values to possible future market price levels is illustrated in table 14.

At lower-limit prices, both opportunities are even more uneconomic after tax than on a before-tax basis in all taxation jurisdictions considered. While taxation sharply reduces the incentive to invest at upper-limit prices, the two projects remain very attractive throughout Canada.

In terms of competitive ranking among provinces, the Quebec, Saskatchewan, and Manitoba tax systems inflict the least damage on the negative tungsten project indicators at lower-limit prices. Considering upper-limit price possibilities, the Saskatchewan and Nova Scotia taxation regimes provide the greatest investment incentive.

For the gold mine development opportunity, the tax policies in Manitoba, Saskatchewan, and New Brunswick are least burdensome at lower-limit prices. Assuming upper-limit price conditions, the Quebec, Saskatchewan, Nova Scotia, and New Brunswick tax systems provide the strongest motivation for investment.

In both cases, taxation policies in British Columbia clearly have the most punitive effects on the after-tax investment criteria.

Table 13

EFFECT OF TAXATION ON ECONOMIC INDICATORS: EASTERN CANADA BASE CASE CONDITIONS

	Tungsten Project		Gold Project	
	Net Present Value at 10% ($ million)	Rate of Return (percent)	Net Present Value at 10% ($ million)	Rate of Return (percent)
Before-tax results	75.9	18.5	8.5	25.5
After-tax results				
Taxation regime:				
Nova Scotia	26.9	13.6	3.2	17.1
New Brunswick	19.1	12.8	3.0	17.0
Newfoundland	14.8	12.1	1.8	14.1
Quebec	21.5	13.1	3.3	17.3
Ontario	17.0	12.5	2.4	15.5
Manitoba	19.5	12.8	2.8	16.4
Saskatchewan	23.6	13.3	3.1	16.7
British Columbia	0.0	10.0	1.2	12.7

Table 14

SENSITIVITY OF AFTER-TAX NET PRESENT VALUE TO METAL PRICE VARIANTS: EASTERN CANADA BASE CASE CONDITIONS

	After-Tax Net Present Value at 10% ($ million)			
	Tungsten Project		Gold Project	
	Lower-Limit Prices	Upper-Limit Prices	Lower-Limit Prices	Upper-Limit Prices
Before-tax results	-73.5	251.6	-6.5	30.2
After-tax results				
Taxation regime:				
Nova Scotia	-90.4	118.2	-8.0	14.7
New Brunswick	-90.4	110.5	-7.8	13.9
Newfoundland	-90.8	103.9	-9.2	12.4
Quebec	-80.8	107.2	-8.1	15.4
Ontario	-90.5	97.7	-8.6	13.1
Manitoba	-85.5	107.4	-7.4	13.4
Saskatchewan	-83.1	118.9	-7.6	14.6
British Columbia	-105.5	83.9	-9.4	11.2

Level and Components of Total Tax Payments

Variations in the level and components of total tax payments, measured by present values discounted at 3 percent, are illustrated in figure 9 for the tungsten project and in figure 10 for the gold mine development opportunity.

The amount of tax revenue collected by government is the complement of the after-tax investment incentive. Thus, we expect to find more tax collected from projects in those provinces which offer relatively unfavourable after-tax incentives for investment. In the case of the tungsten project, the taxation system in British Columbia raises the most tax, followed somewhat distantly by Ontario, Newfoundland, and New Brunswick. The Nova Scotia, Saskatchewan, and Quebec tax regimes collect the least amounts of revenue. For the gold opportunity, British Columbia again collects the most tax, followed by Newfoundland. The tax systems in Quebec, Saskatchewan, and Nova Scotia are characterized by the lowest levels of taxation payment.

Striking differences are also shown in the make-up of tax revenues among provinces. In the case of the tungsten project (figure 9), the federal corporate income tax component varies from 48 percent of total payments in Nova Scotia to 34 percent in British Columbia; provincial corporate income tax, from 25 percent in British Columbia to 8 percent in Quebec; combined provincial mining tax and royalty, from 43 percent of total tax payments in Quebec to 14 percent in Nova Scotia; and non-profit taxes from 16 percent in British Columbia to 5 percent in Quebec. Similar but somewhat less pronounced differences in provincial tax make-up may be noted in figure 10 for the gold project.[28]

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28. It is perhaps surprising that the non-profit taxes considered here represent such a small proportion of total government revenues; 5-16 percent for the tungsten opportunity and 7-17 percent for the gold project. The source study shows that the non-profit tax proportion increases marginally when taxation is levied on an integrated company basis. However, this increase is more substantial if proportions are based on tax payments discounted at 10 percent rather than the 3 percent rate used here.

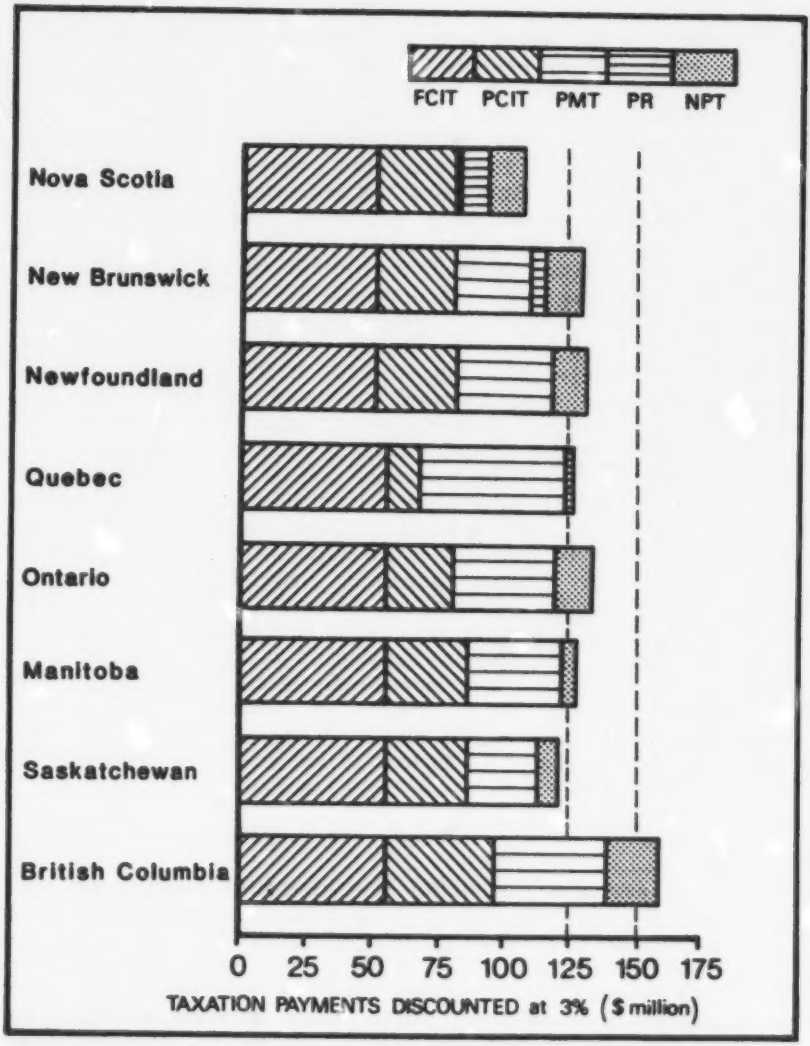

Figure 9. Total Tax Payments and Components: Tungsten Project, Eastern Canada Base Case Conditions

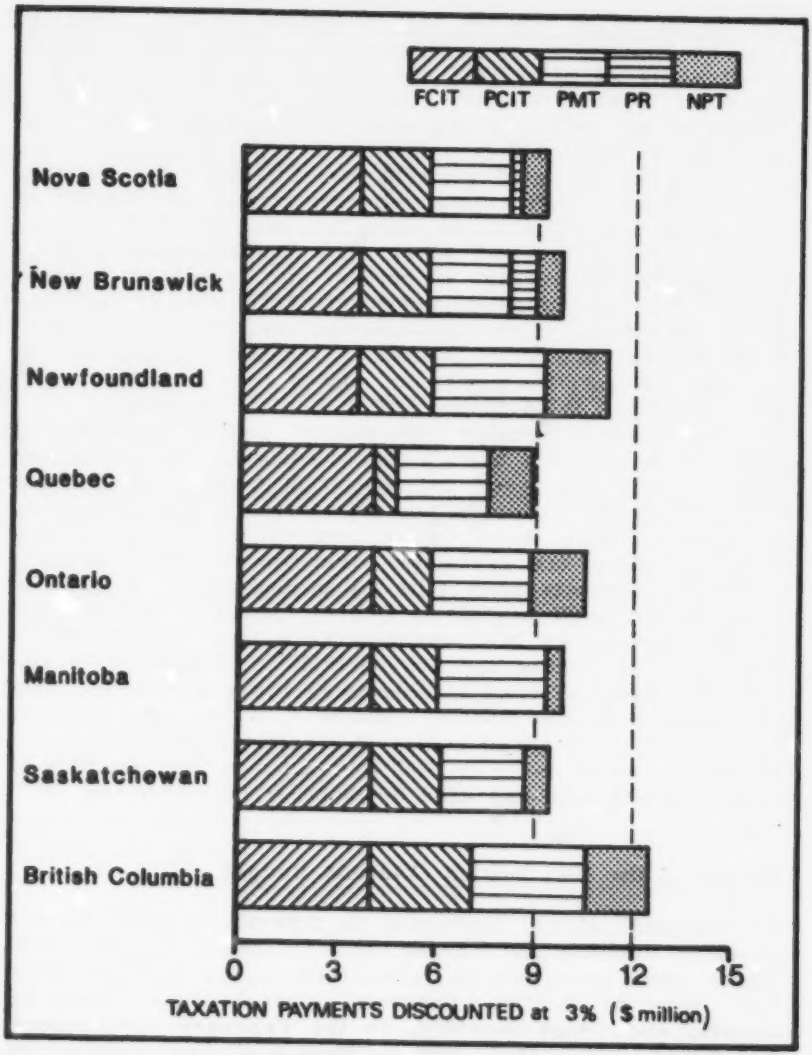

Figure 10. Total Tax Payments and Components: Gold Project, Eastern Canada Base Case Conditions

Incidence of Taxation

The incidence of taxation from a mining company viewpoint may be illustrated by comparing the company's after-tax profit share of before-tax net present value with the governments' taxation share. The governments' share may be viewed as an "effective tax rate". This income-based indicator of tax incidence is presented in figures 11 and 12 for the tungsten and gold projects respectively. On average, the company's profit share represents only 24 percent of the before-tax value of the tungsten mine, and 30 percent of the value of the gold mine. The complementary government tax shares average 76 percent and 70 percent respectively. For the tungsten opportunity, the company-government proportions vary from 35-65 percent in Nova Scotia to 0-100 percent in British Columbia. Similarly, in the case of the gold project, the profit-tax shares vary from 39-61 percent in Quebec to 14-86 percent in British Columbia.

In order to provide perspective on the importance of taxation in a mine's overall cost structure, figure 13 presents an expense-based comparison of taxes. Total taxes incurred by the tungsten and gold projects are expressed, in present value terms, as a proportion of total project costs including tax payments. For the tungsten project, total tax payments vary from 14 percent of total costs in Nova Scotia, to 21 percent in British Columbia. In the case of the gold mine, tax payments vary from 14 percent of total costs in Quebec and Nova Scotia, to 19 percent in British Columbia. Viewed in this way, the incidence of taxation appears rather modest. However, as we have seen, it is the more pronounced impact of taxation costs on the profit margin which is of critical importance to the viability of exploration targets and mine development opportunities.

Effects of the 1985 British Columbia Budget

The original study, conducted in 1984-85, applied the tax systems existing in Canada at the beginning of 1985. There have been several announced policy changes since that time in British Columbia, Saskatchewan, Quebec, Ontario and, most recently, in the February 1986 federal budget.[29] This final section illustrates the updating of

29. The main features of these tax changes are summarized as follows.
British Columbia: reduction in non-profit taxes as outlined in text.
Saskatchewan: proposed changes to depreciation rates

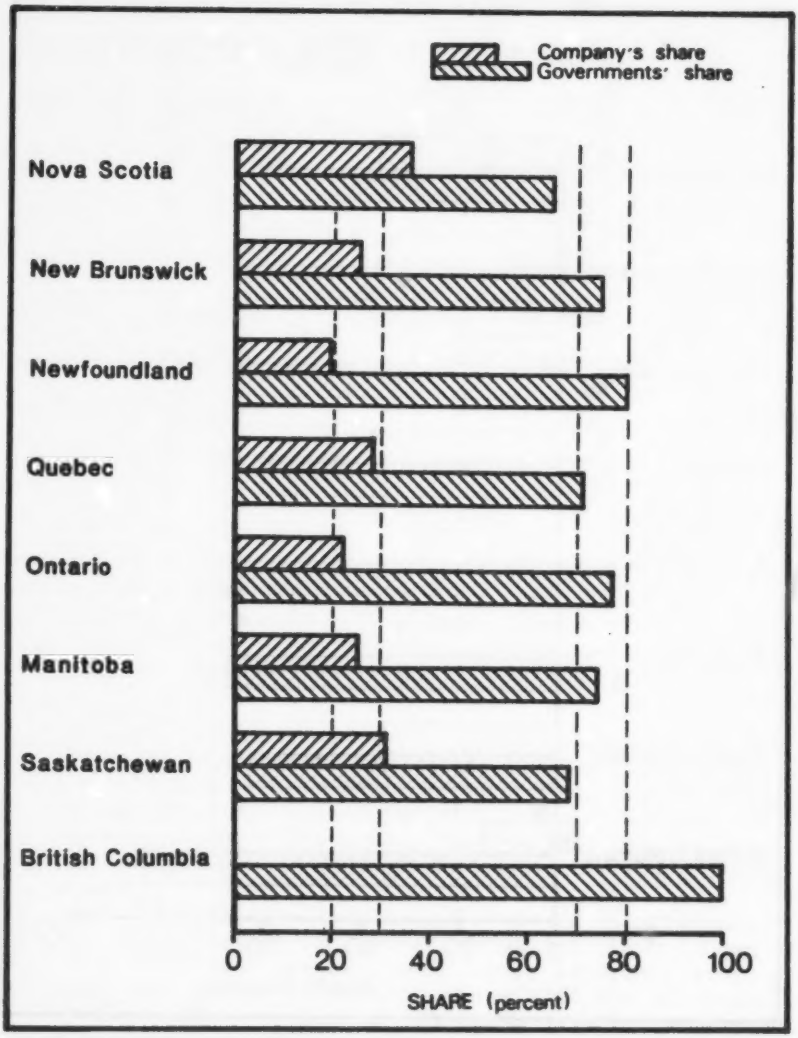

Figure 11. Company and Government Shares of Before-Tax Net Present Value Discounted at 10%: Tungsten Project, Eastern Canada Base Case Conditions

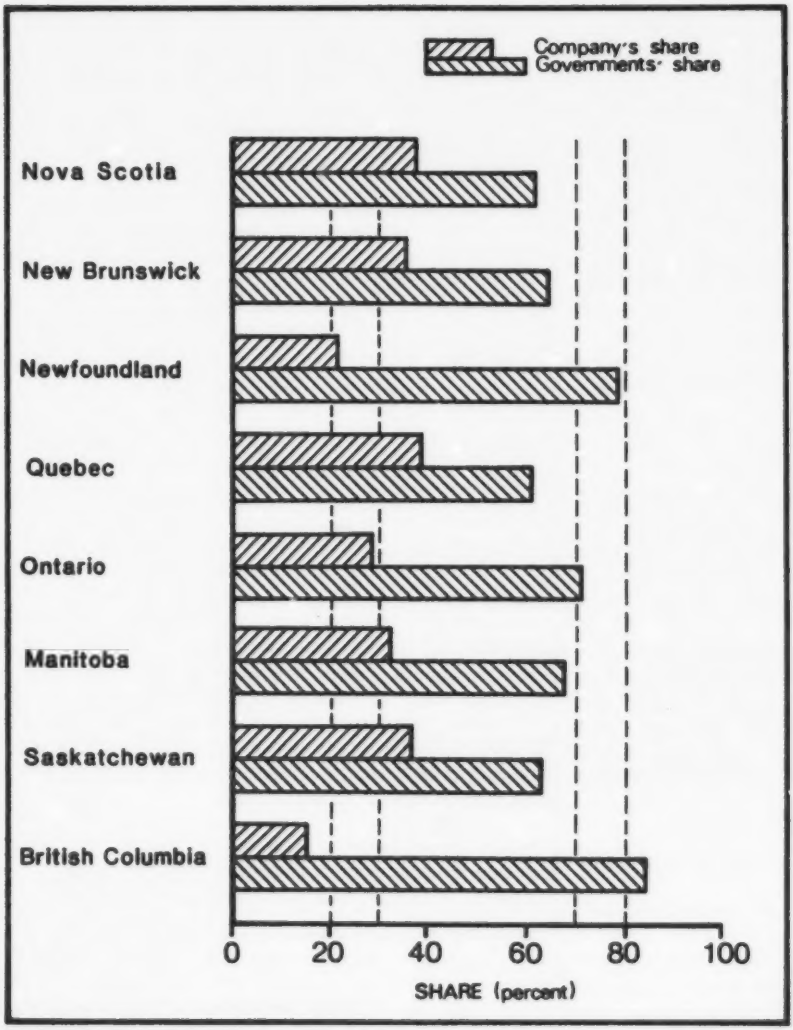

Figure 12. Company and Government Shares of Before-Tax Net Present Value Discounted at 10%: Gold Project, Eastern Canada Base Case Conditions

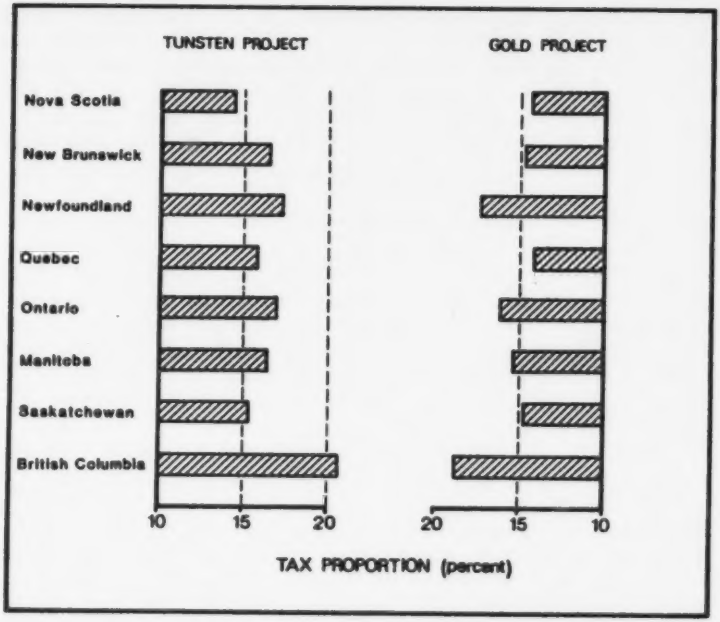

Figure 13. Total Tax Payments Expressed as a Proportion of the Present Value of Total Costs and Taxes Discounted at 10%: Eastern Canada Base Case Conditions

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for mining tax purposes. Capital expenditures for mine development and mine plant and machinery would be allowable at 100 percent, with other capital costs being generally depreciable at 30 percent per year declining balance (currently, most capital expenditures are allowable at 15 percent per year on a straight-line basis).

Quebec: the April 1985 budget replaced the graduated tax rate schedule for Quebec mining tax (15 to 30 percent of annual taxable profit above $250,000) with a flat rate tax of 18 percent above $500,000 of annual profit. Also, system of refundable credits for losses introduced and loss carry-forward provisions changed.

Ontario: the October 1985 budget, following Quebec's lead, replaced the graduated Ontario mining tax system (15 to 30 percent of annual taxable profit above $250,000) with a 20 percent flat rate of tax above $500,000. Maximum processing allowance reduced from

comparative study results by examining the effects of changes in non-profit taxes introduced in the March 1985 British Columbia Budget.[30]

The following four announced budget measures are considered:

- reduction in the provincial fuel tax rate for off-road use of motor fuel to 7 percent of the pre-tax selling price;
- elimination of the corporation capital tax except as it applies to certain large banks;
- elimination of property taxation on machinery and equipment for both school and non-school purposes;
- reduction in school property tax rates for industrial and commercial property from a ratio of 3.4:1 to a ratio of 2:1 of residential tax rates.[31]

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65 percent to 50 percent of income. Also, three modest changes proposed to Ontario corporate income tax system.

Federal: February 1986 budget announced four main changes to federal corporate income tax - 3 percent surtax on all companies to replace 5 percent surtax on large companies in 1987; reduction of the tax rate from 36 percent to 33 percent over three years from 1987; immediate elimination of the inventory allowance; phase out of 7 percent and 10 percent investment tax credit provisions by 1989 (20 percent investment tax credit in maritime provinces and Gaspé region of Quebec to remain).

30. For details, see Budget 1985, The Honourable Hugh Curtis, Minister of Finance, delivered in the Legislative Assembly, Victoria, March 14, 1985, 97 pp. The summary results presented here are based on Locational Aspects of Mine Development Economics: Effects of the 1985 British Columbia Budget, B.W. Mackenzie, D.W. Davis, and M.L. Bilodeau, prepared for Ministry of Energy, Mines and Petroleum Resources, Province of British Columbia, Centre for Resource Studies, February 1986, 41 pp.

31. The reduction in the provincial fuel tax is immediate. The other three changes are being phased in over the 1985-87 period. We assume that the phase-in is complete, so that the projected 1987 tax system would be in effect. We have not considered the 50-percent reduction announced in school property tax on new industrial investment in non-municipal areas for the period 1986-90 because of its temporary nature.

The overall reduction in British Columbia non-profit taxes is shown to be substantial, particularly for the capital-intensive open pit tungsten project. For base case conditions (figures 3-4), total undiscounted non-profit tax payments are reduced by 41 percent and 24 percent for the tungsten and gold projects respectively.[32] Nevertheless, non-profit taxes in British Columbia remain higher than in any of the other provinces.

Updated findings are presented in table 15, paralleling the results presented in tables 13-14 and figures 9-13. A marked improvement in the viability of the tungsten and gold opportunities located in British Columbia is shown to be associated with the 1985 budget changes. While British Columbia still imposes the heaviest burden of taxation, the gap with other jurisdictions narrows considerably.

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32. Elimination of property taxation on machinery and equipment is found to be the main reason for these reductions. Removal of the corporation capital tax is also significant.

Table 15

EFFECTS OF 1985 BRITISH COLUMBIA BUDGET: EASTERN CANADA BASE CASE CONDITIONS

	Tungsten Project		Gold Project	
	British Columbia I	British Columbia II	British Columbia I	British Columbia II
After-Tax Net Present Value at 10% ($ million):				
Expected prices	0.0	6.5	1.2	1.5
Lower-limit prices	-105.5	-93.6	-17.6	-14.5
Upper-limit prices	83.9	89.5	33.6	34.2
Total Tax Payments Discounted at 3% ($ million):	164.3	153.4	12.4	12.0
Company and Government Shares of Before-Tax Net Present Value (percent):				
Company's share	0.0	8.5	14.1	17.5
Governments' share	100.0	91.5	85.9	82.5
Total Tax Payments Expressed as a Proportion of the Present Value of Total Costs and Taxes Discounted at 10% (percent):	20.6	19.2	18.8	18.2

British Columbia I: pre-budget conditions assumed in original study
British Columbia II: system incorporating 1985 budget changes

8. COMBINED IMPACT OF REGIONAL CONDITIONS AND TAXATION POLICIES

Having separately evaluated and compared the effects of regional conditions and taxation policies, the combined impact of these locational factors on mine development economics and exploration potential is examined here. To do this, the before-tax regional variants are combined with appropriate provincial tax regimes for the evaluation of after-tax economic indicators.

After-Tax Investment Incentive

After-tax measures of investment incentive are presented in table 16. In the case of the tungsten project, the Nova Scotia, Saskatchewan, and Quebec locations provide the greatest motivation for investment while British Columbia is shown to be the least favourable location. For the gold opportunity, the Nova Scotia, New Brunswick, and Quebec sites provide the most investment incentive, while British Columbia once again represents the least competitive location for investment. The tungsten and gold projects situated in British Columbia are both uneconomic for the assumed conditions. Generally speaking, the regional and taxation rankings appear to be positively correlated. Thus, the combined impact of these locational components tends to widen differences in competitive position among provinces.[33]

Sensitivity of After-Tax Investment Incentive to Market Price Variants

Expected market prices are used in table 16 to rank provinces in terms of relative favourability for investment. The more general validity of these findings is examined by evaluating the sensitivity of after-tax net present value to the lower-limit and upper-limit price projections. Table 17 presents the results of this sensitivity analysis. The negative after-tax net present values at lower-limit prices only serve to indicate that, if these market conditions were to prevail, the tungsten and gold projects would be quite uneconomic throughout Canada. Provincial rankings at both lower- and upper-limit price levels are generally consistent with those shown for expected prices.

33. Newfoundland is the main exception, regional and taxation differences tending to cancel.

Table 16

COMBINED IMPACT OF REGIONAL CONDITIONS AND TAXATION POLICIES ON INVESTMENT INCENTIVE

Province	Tungsten Project		Gold Project	
	Net Present Value at 10% ($ million)	Rate of Return (percent)	Net Present Value at 10% ($ million)	Rate of Return (percent)
Nova Scotia	26.9	13.6	3.2	17.1
New Brunswick	19.1	12.8	3.0	17.0
Newfoundland	14.8	12.2	1.8	14.1
Quebec	20.1	12.9	2.3	14.8
Ontario	15.5	12.2	1.5	13.2
Manitoba	18.1	12.6	1.9	14.2
Saskatchewan	22.2	13.1	2.1	14.4
British Columbia	-10.9	8.5	-2.5	5.4

Table 17

SENSITIVITY OF AFTER-TAX NET PRESENT VALUE TO METAL PRICE VARIANTS: COMBINED IMPACT OF REGIONAL CONDITIONS AND TAXATION POLICIES

Province	After-Tax Net Present Value at 10% ($ million)			
	Tungsten Project		Gold Project	
	Lower-Limit Prices	Upper-Limit Prices	Lower-Limit Prices	Upper-Limit Prices
Nova Scotia	-90.4	118.2	-8.0	14.7
New Brunswick	-90.4	110.5	-7.8	13.9
Newfoundland	-90.8	103.9	-9.2	12.4
Quebec	-82.1	105.8	-9.6	14.5
Ontario	-91.9	96.8	-10.1	12.3
Manitoba	-86.8	106.1	-8.9	12.6
Saskatchewan	-84.3	117.5	-9.1	13.8
British Columbia	-123.0	74.9	-11.7	8.3

Breakeven Ore Grades

Finally, the after-tax effects of location are appraised in a way which is useful for exploration planning. Instead of assuming a deposit grade and deriving economic indicators, a minimum acceptable economic result is specified (in this case, a 10-percent rate of return) and the ore grade required to yield this breakeven value is assessed. The chances of exploration success are an inverse function of these breakeven grades.

Findings are illustrated in figure 14. The after-tax breakeven ore grades are shown to vary significantly, paralleling the difference in economic indicators presented in table 16. The breakeven grade requirement for the tungsten deposit varies from .15 percent WO_3 at the Nova Scotia location to .18 percent WO_3 in British Columbia. In the case of the gold deposit, the minimum acceptable grade changes from 8.1 grams per tonne at the Nova Scotia and New Brunswick sites, to 10.5 grams per tonne in British Columbia. Thus, undiscovered gold deposits of the size and type assumed with grades of between 8.1 and 10.5 grams per tonne represent economic exploration targets in the former cases but would be uneconomic in the latter situation.

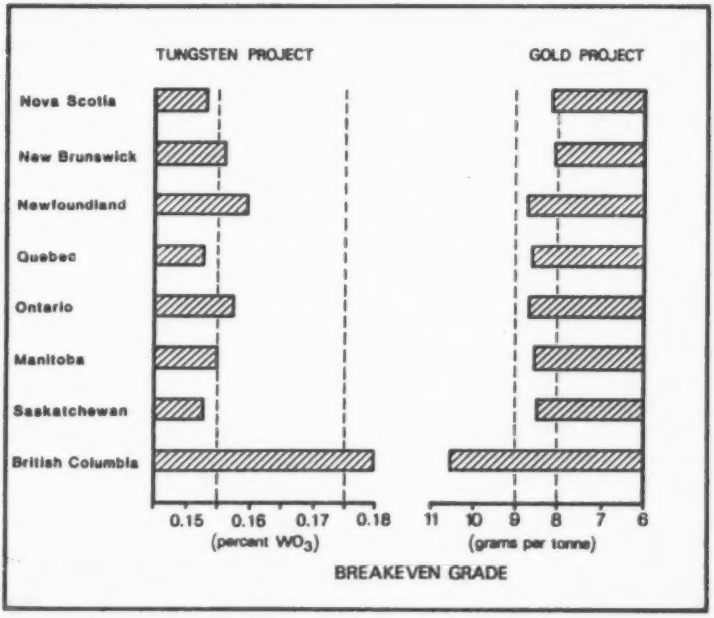

Figure 14. Combined Impact of Regional Conditions and Taxation Policies on Breakeven Ore Grades

7. SUGGESTIONS FOR FUTURE WORK

Utilizing the evaluation procedure developed here, future work should be undertaken to update the appraisal and to analyze the competitive position of mining within Canada more comprehensively. The following areas of research are suggested for consideration.

Improve Estimates of Before-Tax Economic Conditions

The comparison of before-tax locational conditions could be enhanced in several ways:

- analyze more extensive and up-to-date time series data on wage and salary rates, and power costs;
- assess the sensitivity of mining project viability to a non-union workforce;
- determine whether geographical differences in construction and mine labour productivity can be measured and, if so, incorporate in the analysis;
- make province-specific estimates of before-tax locational conditions rather than attempting to generalize by region;
- evaluate less-accessible site variants within each province.

Update Income and Mining Taxation Policies

The incremental and combined effects of new tax measures introduced in 1985 and 1986 should be examined along the lines of the 1985 British Columbia budget update summarized in chapter 5. This appraisal would incorporate:

- proposed changes to Saskatchewan mining taxation;
- mining tax measures announced in the April 1985 Quebec budget;
- in Ontario, mining and income tax changes introduced in the October 1985 budget;
- corporate income tax modifications proposed in the February 1986 federal budget.

Extend Non-Profit Tax Estimates

The present study represents a first attempt to come to grips with non-profit tax payments. Work in this area should be extended to include:

- a range of possible property tax payments in each case. We have found property taxes particularly difficult to estimate with any semblance of reliability. Most importantly, it is hard to generalize on property tax burdens within each province. Evaluation of the sensitivity of comparative results to possible ranges of values would be more realistic;

- provincial tax on electricity used by mining operations where applicable, e.g. Manitoba, Saskatchewan, and British Columbia;

- federal sales tax, currently only implicit in our cost estimates;

- tariffs on imported machinery and equipment;

- comprehensive analysis of non-profit taxes in Canada including underlying policy rationale, offsetting services, and effects on economic viability.

Develop Wider Range of Representative Mining Projects

One aspect of the effects of location on the economics of prospective exploration targets and mine development opportunities is the distance and cost associated with transporting the mineral commodities produced from the minesite to the market place. Although our evaluation procedure incorporates this variable, the gold bullion and tungsten concentrate products of the mining projects considered have such high unit values that economic results are essentially insensitive to these transportation costs. To examine this aspect of locational economics, one or two similar case studies might be carried out for lower unit value mineral commodities, for example:

- a medium-size open pit industrial mineral project;
- a large open pit coal project.

More generally, these types of opportunity would also help broaden our coverage to a wider spectrum of Canadian mining activities. In this regard, an underground nonferrous metal project would also not be out of place.

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